MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EMF4096 – RADAR SYSTEMS DESIGN AND ANALYSIS

(TE)

15 MARCH 2019
3:00 P.M- 5:00 P.M
(2 Hours)

INSTRUCTION TO STUDENT

1. This examination paper consists of 7 pages including cover page with 4 Questions only.

2. Attempt **ALL** the questions. Each question carry equal marks and distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided. Please number your answers clearly.

Question 1

(a) Briefly explain about;

(i) Doppler frequency shift for opening target

[3 marks]

(ii) Monostatic radar equation for a point target

[3 marks]

(b) In a radar system, the radar signal is used to determine the range of a moving vehicle. In this system, an *L*-band radar is used with an operating frequency of 5000 MHz. The radar cross section is 10 m^2 with maximum range of detection of 220 meters. The antenna directivity is 20 dB with a pulse width of 10 ns. The minimum detectable signal is to be 5×10^{-13} W with unity antenna efficiency. Determine the following:

(i) Pulse repetition frequency (PRF) if range measurement must be unambiguous.

[2 marks]

(ii) Resolution in range.

[2 marks]

(iii) Duty cycle.

[3 marks]

(iv) Average power required to detect a radar cross section vehicle at a maximum range.

[3 marks]

(c) Figure Q1(a) shows a radar system with frequency 10 GHz and velocity 250 m/s to the radar target with velocity 175 m/s. Determine the doppler frequency shift measured by the radar system.

Figure Q1(a)

[3 marks]

Continued...

(d) Figure Q1(b) shows a basic block diagram of radar system. Modify the circuit to become a range detector radar system which consider a fast fourier transform.

[6 marks]

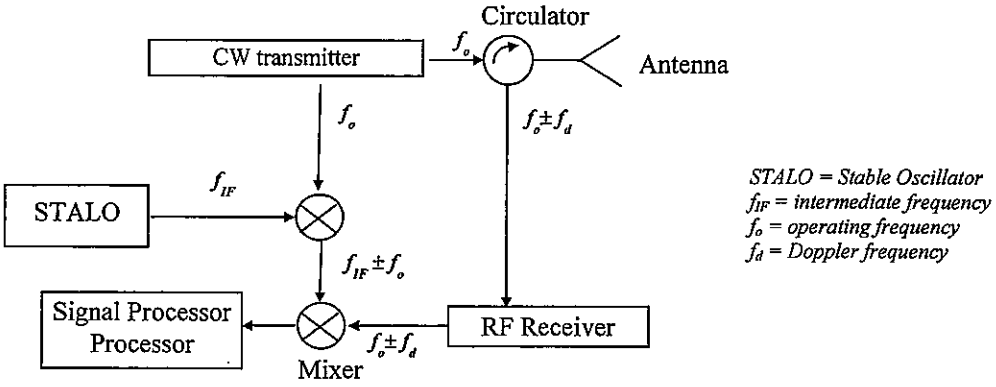


Figure Q1(b)

Continued...

Question 2

(a) Figure Q2 shows a Frequency Modulation Continuous Wave (FM-CW) radar signal with triangular frequency modulation.

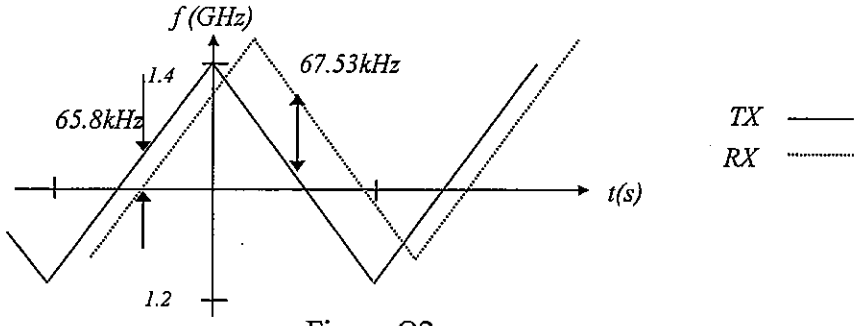


Figure Q2

(i) If the target is located at 250 m from the radar system, determine the intermediate frequency (f_{IF}) measured by the radar?

[5 marks]

(ii) If the target is an aircraft moving with a velocity of 100 m/s, determine $f_{IF,UP}$ and $f_{IF,DOWN}$. Sketch the instantaneous RF frequency for the above target.

[5 marks]

(b) A synthetic aperture radar instrument has a range resolution of 10 m in the slant range direction and an azimuth resolution of 15 m. Suppose that the pixel spacing is exactly equal to the resolution. Data are processed on the satellite and sent to Earth with one byte representing each pixel.

(i) What is the required bandwidth to achieve a range resolution of 10 m in the slant range if Chirp (Linear FM Pulse) is employed in this Synthetic Aperture Radar (SAR) system.

[4 marks]

(ii) What is the ground range resolution of this instrument if it is operated with an incidence angle of 30°? What is the ground range resolution if the incidence angle is increased to 60°?

[3 marks]

(iii) At what incidence angle should the radar use to obtain "square"pixels on the ground?

[3 marks]

(c) Provide FIVE(5) important Synthetic Aperture Radar (SAR) system parameters.

[5 marks]

Continued...

Question 3

(a) Describe about Radar Cross Section (RCS) dependency on wavelength.

[6 marks]

(b) A radar has the following specifications: transmitted power P_t, gain of antenna G, pulse width $\tau = 2$ μs, antenna beam width $\theta = 3°$, and wavelength $\lambda = 5$ cm. The radar illuminates an area as shown in Figure Q3. The range from radar to target is 10 km and the grazing angle, $\psi_g = 30°$. The area has a point target with radar cross section (RCS), $\sigma = 10$ m^2. The point target is surrounded by grass with a backscatter coefficient $\sigma^0 = -30$ dB.

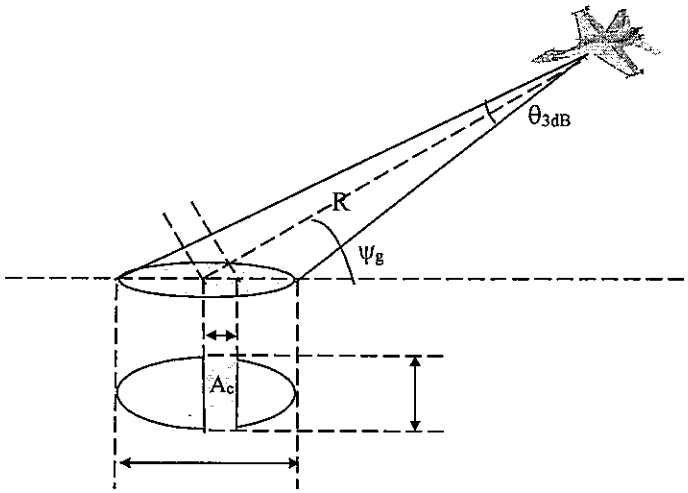


Figure Q3

Calculate the following:

(i) the area illuminated by a single pulse, A_c,

[4 marks]

(ii) the return power solely from the point target,

[2 marks]

(iii) the return power solely from the background A_c, and

[4 marks]

(iv) the signal to clutter (SCR) ratio.

[2 marks]

(c) Consider a monostatic radar operated at 10 GHz. A scattered signal is received from four points on a complex target surface. The first point is 20 km away from the radar, while the other three points are equally spaced at 2m from each other. Determine the effective Radar Cross Section (RCS) in terms of the RCS of those points.

[7 marks]

Continued...

Question 4

(a) Briefly explain SIX(6) phases involved in system analysis.

[6 marks]

(b) Figure Q4 shows the block diagram of an airborne synthetic aperture radar (SAR) system.

(i) Determine the main purpose of using circulator in this design.

[2 marks]

(ii) Find out the main disadvantage of the circulator if we wish to transmit a high power signal. Modify and create the circuit to address this disadvantage and draw an appropriate figure to illustrate the design.

[5 marks]

(iii) Determine the main function of LNA in the receiver.

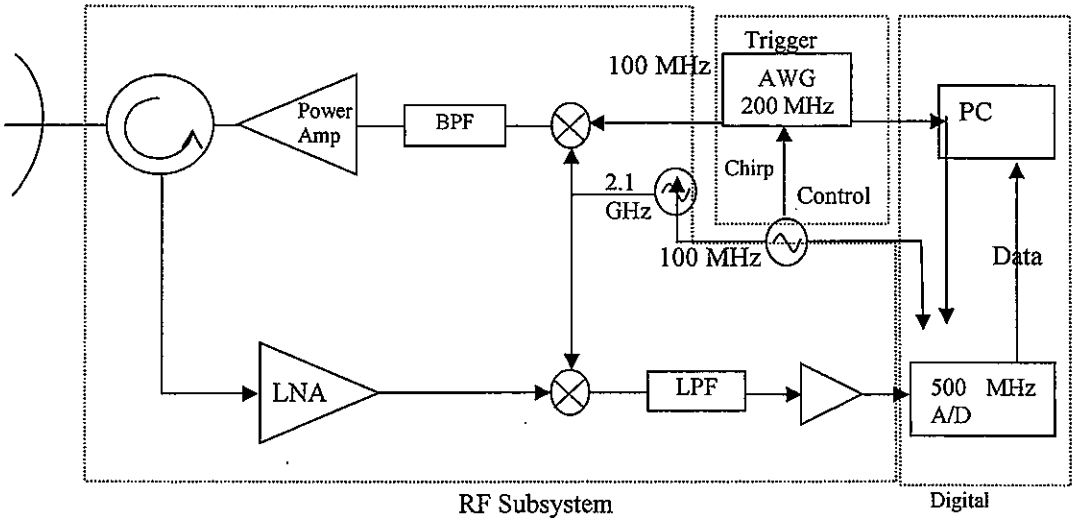
[2 marks]

(iv) Determine the main function of the 100 MHz oscillator in this design.

[2 marks]

(v) A 500 MHz Analog to Digital Conversion (A/D) is used to sample the return echo. Find the minimum allowable sampling rate in this design.

[2 marks]



BPF = band-pass filter
LNA= low noise amplifier
LPF= low pass filter
A/D = analog to digital

Figure Q4

Continued...

(c) Radar filter is commonly used to pass the frequencies within certain range and attenuate frequencies outside that range. Sketch a diagram of radar filter which consists of passband center frequency, upper half power frequency, lower half power frequency, upper rejection frequency and lower rejection frequency.

[6 marks]

End of Paper